# Systems Engineers

Track for the U.S. Army's fleet of tracked vehicles is expensive to replace, and, if it fails, the vehicle and crew can potentially be stranded in hostile territory. To keep warfighters safe and prevent costly failures, the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) operates two labs that study the performance of tracked vehicle components.

An M1A1 Abrams Main Battle Tank provides covering fire during a clear, hold and build exercise. The Elastomer Improvement Program (EIP) has established baseline hyperelastic data that successfully developed, optimized and delivered an Abrams T-158LL bushing model so warfighters have the reliability they depend on for maneuverability and battlefield survivability. (U.S. Marine Corps photo by LCPL Kelsey J. Green.)

# Keep Vehicles on Track

Chris Williams

## Center Guide Wear Simulator

Center guides are small components that play a major role in keeping tracked vehicles on track. The component is part of the vehicle's track shoe and runs between the road wheels to keep the track aligned and on the vehicle. During the vehicle's operation, the center guide's contact with other tracked components causes wear and degradation.

To understand how the components interact before they are integrated into a vehicle, TARDEC officials test the components on the Center Guide Wear Simulation Machine located at an off-site academic research center. "You tend to get a lot of side load, friction and wear between the center guide and the back of the road wheel," explained Eric Blash, a mechanical engineer on TARDEC's Track and Suspension Team. "The Center Guide Wear Simulation Machine is basically a large drum. We fasten center guides to it and spin it around, simulating a vehicle moving at 20 mph. The center guides ride against the wear surface of a road wheel with a specified contact load between the components. It's a quick and cost-effective way to see if a material is suitable for the application before we spend a lot of money on vehicle testing."

As the Army develops lighter vehicles, the simulator plays an essential role in testing new materials and components. Track shoes are traditionally made from steel.

**Soldiers change the tracks on their Bradley Fighting Vehicle. Testing done at TARDEC provides an understanding of how a vehicle's components interact when in use, a capability that stand-alone component testing cannot provide. (U.S. Army photo by SGT Dan Purcell.)**

In an attempt to decrease vehicle weight, the Army has experimented with various lightweight materials, including aluminum metal track with silicon carbide inserts that were placed on the center guides and a diverse array of materials and coatings for wear rings and road wheels.

When new materials and components are added to the test shoe, the simulation machine is used to gauge how quickly the components will wear. "When you use a lighter-weight aluminum road wheel, you typically have a steel wear ring attached to it," explained Blash. "That wear ring is going to be what actually contacts the center guide. It's expensive to build that wear ring and then fasten it to the road wheel. There's been experimentation with different coatings that improve the wear properties of the aluminum wheel. So, we can use the simulation machine to test the center guide material itself, or we can test new materials for the wear ring or the road wheel."

The testing provides TARDEC engineers with an understanding of how the components interact with each other when in use, a capability that stand-alone component testing cannot provide. The simulation machine also allows researchers to understand the wear properties of various materials, properties that would be difficult to gauge without physical tests. "Wear is a funny beast," Blash remarked. "We can do a standardized wear test that compares materials, but until you simulate the actual working conditions you won't know exactly how those two materials are going to interact with each other."

The simulation machine does not replace Army qualification standards but, rather, is used to understand tracked vehicle components as they interact before they are integrated into a vehicle system. "We really utilize it for the cost-savings benefit," Blash revealed. "It's not a qualifications test — it's an engineering evaluation. It basically provides another data point for us to make the decision of whether or not we should spend the money on a field test."

## Bushing Testing and Evaluation

The most common track failures stem from the system's elastomeric components, such as bushings, which hold essential pins in place to keep tracks aligned. TARDEC's Elastomer Improvement Program (EIP), a state-of-the-art research and development (R&D) facility designed for testing, categorizing and improving rubber compounds for tracked vehicle systems at the Detroit Arsenal, features a bushing tester, which allows engineers to understand bushing properties without incurring the cost of a vehicle test.

"The EIP exists to come up with more relevant tests, protocols and techniques to better duplicate our failure modes and make better intuitive decisions on direction for research," explained Bill Bradford, an R&D scientist with TARDEC's Mobility R&D Center. "In the past, we conducted screening and qualification testing based on materials R&D methodology developed in the 1960s. Advances in material, testing equipment, sensors, computers and electronics have improved test equipment sensitivity and reliability. Laboratory tests with components will always be at risk with respect to duplicating actual field performance. However, understanding the predominant failure modes, optimizing state-of-the-art test equipment and methodology to closely

**A construction mechanic greases the tracks of a land excavator. Before integrating tracks and other components into a vehicle, TARDEC officials test the components on the Center Guide Wear Simulation Machine to reduce maintenance costs, improve life-cycle performance and keep warfighters out of harm's way. (U.S. Army photo by PFC Eric Liesse.)**

**R&D Scientist William Bradford uses a DMTA testing tool to examine bushing properties. DMTA testing provides a true assessment of bushing properties during the component's life cycle and insight into required material improvements. (U.S. Army TARDEC photo by Chris Williams.)**

mimic field failures, brings us one step closer to screening improved components in the laboratory," Bradford continued.

The result was the procurement of an R&D bushing test stand and development of test methodology that would leverage production bushings and identify radial and torsional loads that would result in duplicating the failure mode to the T-158LL track bushings. Over the last 18 months, this capability has provided two new improved bushing designs that are expected to improve the durability of the T-158LL bushing by more than 50 percent.

**EIP testing determined that bushings undergo 55-percent deterioration after assembly, which can lead to track and component failure. TARDEC researchers are trying to create bushings made of a more durable, consistent material that will improve track durability and performance in harsh terrain. (U.S. Army TARDEC photo by Chris Williams.)**

In conjunction with the test stand development, the EIP lab has established baseline hyperelastic data that was used to successfully develop, optimize and deliver a Finite Element Analysis (FEA) model for the Abrams T-158LL bushing. This capability is a major breakthrough, providing a functional FEA model for design optimization with respect to maximum stress, energy input per loading step and the impact of insertion, radial and torsional loads. This capability, in concert with the elastomer test screening process, has provided the roadmap forward for improving the component's durability by 50 percent, resulting in significant savings.

The EIP uses a new testing methodology to extract rubber bushings from track components through specialized shiving techniques that produce consistent sample geometry for dynamic mechanical thermal analysis (DMTA). This testing provides a true assessment of the component's properties during its life cycle and insight into required material improvements.

Bushing testing is also conducted off-site on another type of bushing tester. Although officials at the off-site research center and TARDEC are enhancing bushing testing capabilities through the EIP, the off-site bushing tester is still a useful tool in understanding whether new bushing materials meet rigorous Army standards.

"If a contractor comes in and says they have a new material that they want to use for military track, they go through a series of material property tests, and then we have them produce production-grade T-130 bushings," Blash stated. "We insert them into simulated bores and run radial and torsional load profiles until the bushing meets a certain failure criteria. At that point, we tell them whether or not that is an acceptable material to use to build military track. The failure criterion is based on a certain deflection — once the pin moves a certain amount, we say that bushing has failed. We take the cycle count at that point and look at whether it meets the minimum acceptance criteria."

Bradford believes the R&D activities conducted by TARDEC will continue to expand the Army's understanding and knowledge base to continuously improve track durability, performance and translate into more reliable track systems and reduce life cycle costs. "Our goal is to develop better laboratory R&D tests that mimic actual field failures, increasing the probability of success and reducing the burden and costs associated with full vehicle tests. These laboratories provide us with the capability to evaluate new materials and designs for improved track components, bushings, road wheels, ground pads and road wheel backer pads to support our warfighters," Bradford concluded.

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